Innovation for economic performance: the case of Latin American firms

Working Paper Series

#2013-028

Innovation for economic performance: The case of Latin American firms

Elena Arias Ortiz, Gustavo Crespi, Ezequiel Tacsir, Fernando Vargas and Pluvia Zuñiga

Maastricht Economic and social Research institute on Innovation and Technology (UNU-MERIT)
email: info@merit.unu.edu | website: http://www.merit.unu.edu

Maastricht Graduate School of Governance (MGSoG)
email: info-governance@maastrichtuniversity.nl | website: http://mgsog.merit.unu.edu

Keizer Karelplein 19, 6211 TC Maastricht, The Netherlands
Tel: (31) (43) 388 4400, Fax: (31) (43) 388 4499

UNU-MERIT Working Papers

ISSN 1871-9872

Maastricht Economic and social Research Institute on Innovation and Technology, UNU-MERIT

Maastricht Graduate School of Governance MGSoG

UNU-MERIT Working Papers intend to disseminate preliminary results of research carried out at UNU-MERIT and MGSoG to stimulate discussion on the issues raised.

Innovation for Economic Performance:

The case of Latin American Firms*

May, 2013

Elena Arias Ortiz[1], Gustavo Crespi[2], Ezequiel Tacsir,[2,3] Fernando Vargas,[2] and Pluvia Zuñiga[3]

Abstract

In this note, a wide range of innovation indicators are analysed in order to describe the innovation behaviour of manufacturing firms in LAC using the recently released Enterprise Surveys 2010. The Enterprise Surveys define innovation rates as the share of firms introducing product and process innovations. The survey also measures the proportion of firms investing in research and development (R&D) and filing for intellectual property rights (IPRs). The aim of this note is to understand the main characteristics of innovative firms and to gather new evidence with regard to the nature of the innovation process in the region. Statistics about the performance of LAC firms are provided using different types of indicators to measure firms' innovative behaviour. In particular, differences in innovation performance and effort by country, sector, and key firm characteristics, such as being a multinational or exporter, are explored. Those firms in LAC that are top R&D performers are identified, and the analysis closes with an exploration of firm characteristics that strongly correlate with the probability of being a top R&D performer in the region.

JEL Classification: D22, O3, O33, O34
Keywords: innovation, research and development, Latin America, enterprise surveys

1 Education Division, Social Sector, Inter-American Development Bank.
2 Competitiveness and Innovation Division, Institutions for Development, Inter-American Development Bank.
3United Nations University and Maastricht Economic and Social Research Institute on Innovation and Technology (MERIT), Maastricht, the Netherlands.

*This paper is part of the project RG-T1861 "Policies and Institutions for Productivity in Latin America and the Caribbean" coordinated by the Competitiveness and Innovation Division of the Inter-American Development Bank (IDB) and has been published as an Inter-American Development Bank Technical Note. The Inter-American Development Bank Technical Notes encompass a wide range of best practices, project evaluations, lessons learned, case studies, methodological notes, and other documents of a technical nature. The information and opinions presented in these publications are entirely those of the author(s), and no endorsement by the Inter-American Development Bank, its Board of Executive Directors, or the countries they represent is expressed or implied.

1. Introduction

In the 21st century, economies are becoming more knowledge-based, where innovation (including technological change) is the driver of national competitiveness, development, and long-term economic growth. At the firm level, innovation—the transformation of ideas into new or improved products, services, and production processes— leads to more efficient use of resources, creating sustainable competitive advantages. In addition, innovation is essential to spur economic growth and to raise living standards. Higher research and development (R&D) spending, innovation, productivity, and per capita income reinforce each other and lead to sustained long-term growth (Hall and Jones, 1999; Rouvinen, 2002).

Evidence of the important relationship between R&D, innovation, and productivity has been found in studies of industrialized countries (Griffith et al., 2004; Griffith et al., 2006; Mairesse and Mohnen, 2010; OECD, 2009a). Investing in innovation can have substantial economic payoffs: firms that invest in R&D and other innovation-related activities are better equipped to introduce technological advances and tend to have higher labour productivity than those that do not. Crespi and Zuñiga (2012) report that productivity gaps between innovative and non-innovative firms are much higher in LAC than in industrialized countries. For the typical EU country, the productivity gap is 20 per cent, while for the typical LAC country it is 70 per cent. Thus, LAC has great potential to benefit from investment and policies that foster innovation.

In this paper, a wide range of innovation indicators are analysed in order to describe the innovation behaviour of manufacturing firms in LAC using the Enterprise Surveys database.[2] Enterprise Surveys (ES) define innovation rates as the share of firms introducing product or process innovations.[3] The surveys also measure the proportion of firms investing in R&D and filing for any type of intellectual property rights (IPR), such as patents, trademarks, or copyright applications. The objective is to understand the main characteristics of innovative firms in LAC and to gather new evidence with regard to the nature of the innovation process in the region. Section 2 of the paper reviews the main findings in the literature on the determinants of

[2] The Enterprise Survey is firm-level survey collected in more than 135 countries by the World Bank. This paper focuses on data for the 18 LAC countries and the Caribbean. For more details, see the Technical Appendix.

[3] In this paper, the term "*product innovation*" refers strictly to firms that introduced a new or significantly improved product that is new to the establishment's market in the last 3 years. "*Process innovation*" refers strictly to firms that introduced new or significantly improved processes that are new to the industry in the last 3 years.

innovation in both industrialized and developing countries. Section 3 presents statistics about the level of performance of LAC firms by country and sector of economic activity using different types of indicators to measure firms' innovation behaviour. The ways that innovation relates to firm characteristics in the Latin American context are explored, including how it relates to exporting, and how foreign firms differ from domestic ones. Economic rationales and arguments provided by the literature for each of these evaluations are discussed. Finally, Section 4 identifies the companies that invest in R&D in LAC and explores the firm characteristics that influence R&D spending by top-performing firms in the region.

2. Literature Review

Innovation is fundamental for economic catching-up and raising living standards. Cross-country studies demonstrate a virtuous circle in which R&D spending, innovation, productivity, and per capita income mutually reinforce each other and lead to long-term, sustained growth rates (Hall and Jones, 1999; Rouvinen, 2002) and could even foster job creation from a theoretical point of view (Vivarelli, 2013). Investment in R&D is a source of direct and indirect advantages for firms. There is convincing evidence for industrialized countries showing the positive linkages between R&D, innovation, and productivity at the firm level (Griffith et al., 2004; Griffith et al., 2006; Mairesse and Mohnen, 2010; OECD, 2009a, Mohnen and Hall, 2013). In addition to being a major determinant of technological innovation, investment in R&D also affects the creation of absorptive capacity, a fundamental prerequisite for "learning by doing" and successful catching-up. Internal R&D allows firms to better identify the value of external technology, assimilate and make better use of it, while expanding firms' stock of knowledge (Cohen and Levinthal, 1989; Griffith et al., 2004). Hence, strengthening in-house technological capabilities facilitates the process of assimilation of knowledge spillovers through acquisition of machinery, equipment, and interaction with more developed and foreign firms. Therefore, it is crucial to assess what firms are doing in the areas of innovation and R&D. Do they engage in innovation as part of their competitive strategy? Do they devote resources to R&D? How does innovation impact firm performance and competitiveness?

Investing in innovation, however, can be prohibitive for many firms in developing countries. Given the uncertainty, indivisibility, and the intangible nature of innovation

investments, it is difficult for firms to access to credit for innovation. Some of these constraints are exacerbated by the fact that the returns on innovation can be appropriated by others due to imitation and reverse engineering. Therefore, it is difficult to negotiate a loan over insecure assets and to enter into contracts using knowledge assets as collateral or guarantees.

Public policy is needed to alleviate market failures in innovation investment. In contrast to the OECD countries, fiscal budgets allocated to support innovation in LAC are rather meagre and in general reach a small number of companies in the region (Crespi, 2012). For Latin American firms, public support for innovation activities is essential. Many programs have been evaluated, and existing studies about pioneering programs in operation in the region since the early 1990s show that they have had a positive impact on (i) input additionality (i.e., tax incentives have been effective in increasing business investment in innovative projects and leveraging private resources for these investments); (ii) promoting links between companies and universities; and (iii) output additionality, provided that sufficient time has elapsed since the grant was approved (positive impacts on labour productivity begin to appear only after three to five years after the start of an innovation project).

As far as constraints on innovation are concerned, problems related to securing financing for innovation and the inability of the firms to wait for long periods of time are among the most important obstacles to innovation perceived by firms in Latin America (Navarro et al., 2010; Anlló and Suarez, 2009). It is more difficult for small- and medium-sized firms (SMEs) and young firms to access financing. In addition, there is substantial international evidence confirming that these types of firms are relatively more credit-constrained and face higher cost of capital than large companies (Harhoff and Körting, 1998). These findings have also been confirmed for Chile (Crespi and Alvarez, 2011).

Intellectual property protection is another public policy that intends to alleviate market failures by providing a legal framework to innovators to receive appropriate returns on innovations. Patenting has become an indicator of competitiveness as intellectual assets have grown in importance in international economic transactions. By providing market exclusivity rights over firm inventions that achieve a significant level of novelty and provide new industrial applications, patents allow firms to recoup innovation costs (Griliches, 1990; OECD, 1994;

2009b). The importance of patent protection evolves with the level of economic development[4]. As firms become more innovative—and rely less on imitation as main strategy for catching up—and as economies develop and acquire valuable knowledge assets, policy agents have a vested interest in providing effective patent systems (Ginarte and Park, 1997).

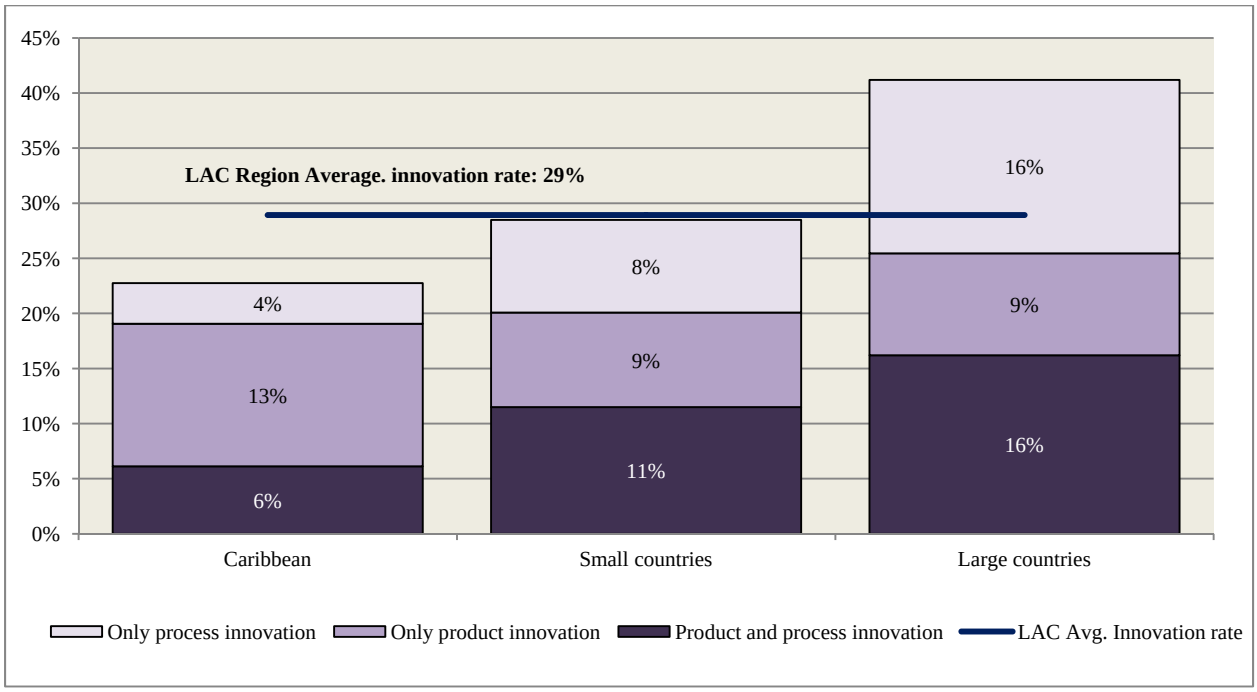
3. Where is Innovation Occurring?

Enterprise Surveys includes data on a number of innovation activities, such as the development of technological products, processes, and non-technological innovation (such as managerial, organization, and marketing practices). Firms are considered to be innovators if they introduced either a product innovation new to the market or process innovation new to the industry in the previous three years. Due to the differences in the innovation processes that drive the two types of innovations, product and process innovation will be discussed separately.

The average innovation rate among manufacturers[5]–that is, the share of firms innovating by introducing a new or significantly improved product or process—is 29 per cent in LAC. This rate is highest in the region's largest countries (Figure 1), and is lower in the small- and medium-sized countries as well as the small Caribbean countries. Moreover, 16 per cent of firms in LAC's largest countries report both a product *and* a process innovation—compared to 11 per cent of firms in small and medium countries and only 6 per cent in small Caribbean countries. The fact that 32 per cent of firms in the large countries innovated a production process (16 with a product innovation and 16 per cent without) suggests that firms in the region's largest economies are adapting more complex products and possibly exploiting economies of scale. By contrast, 13 per cent of firms in the small Caribbean countries report a product innovation *without* an associated innovation in process. The latter fact could imply higher rates of adaptation of either less complex products or simply replicating existing products in the market.

[4] A clear example is analysed by Kim et al. (2013), who show that the catching up latecomers in the software industry in China was initially led by handling the publishing (or distributing) of games developed by foreign firms, then imitating them, and even pirating them occasionally.
[5] All ES data reported in this paper are limited to manufacturers only.

Figure 1. Innovation Rates *(percentage of firms)*



Source: Authors' calculation using Enterprise Surveys 2010.

There are large differences in innovation rates across LAC, reflecting cross-country differences in the structure of economies as well as business and policy environments for innovation. Large countries, such as Argentina, Chile, Colombia, and Peru, rank well above the regional average for innovation indicators.[6] The exception is Mexico, which had weak performance on all innovation indicators.

Within large countries, where the size of the economy allows for comparisons across selected industries—namely, Argentina, Chile, Colombia, Mexico, and Peru—there is further variation across specific manufacturing sectors. Chemical and plastics manufacturers innovate at the highest rate, appreciably higher in product and process innovation rates.

[6] No data are provided for Brazil because the latest round of Enterprise Surveys from Brazil, in 2009, did not include the innovation module used in 2010.

Table 1. Product and Process Innovation Rates

Industry*		**Average****
Food/Beverages	Product	**10.3**
	Process	**12.5**
	Product & Process	**7.5**
Textiles & Garments	Product	**14.9**
	Process	**12.6**
	Product & Process	**14.1**
Chemicals & Rubber/Plastics	Product	**15.2**
	Process	**11.5**
	Product & Process	**23.1**
Fabricated metals & Machinery/Equip.	Product	**10.6**
	Process	**14.8**
	Product & Process	**16.3**

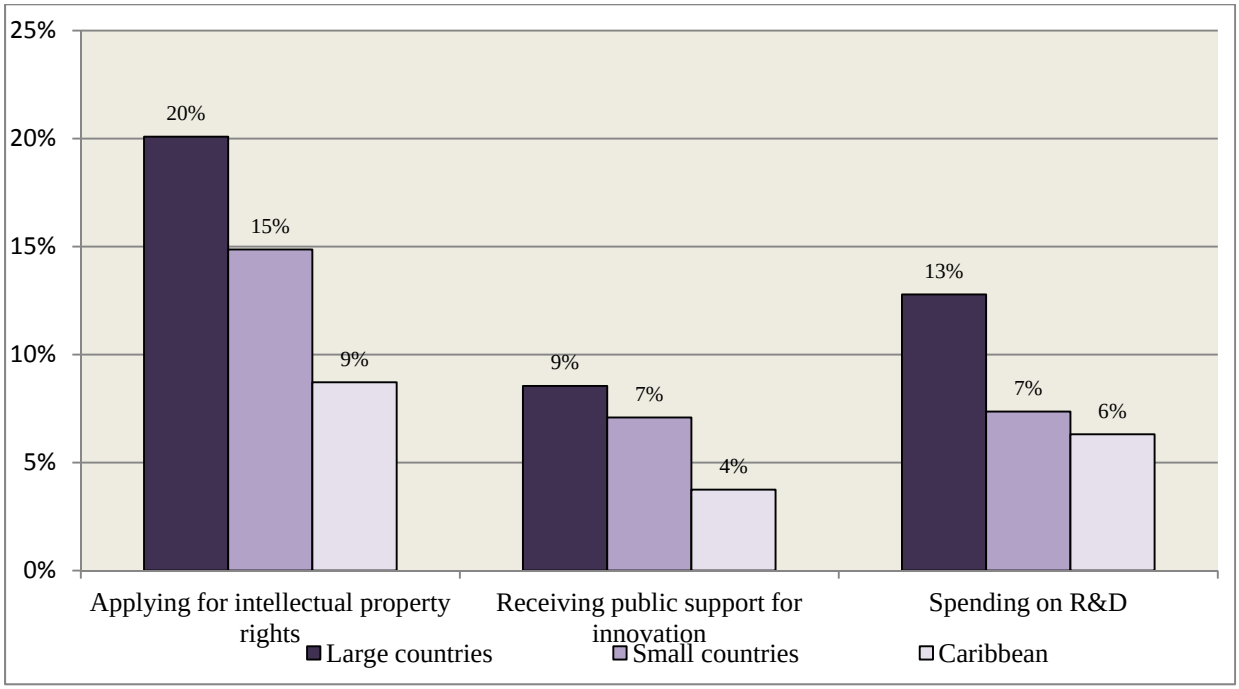
*Average among large countries with comparable data and survey designs (Argentina, Chile, Colombia, Mexico, and Peru)
**Chosen based on stratification designs in selected, large countries
Source: Authors' calculation using Enterprise Surveys 2010.

Given that in the majority of the countries in the region there is no official reporting on R&D expenditures based, for example, on tax returns, answers to this question in the survey are prone to measurement errors and particularly to over-reporting. In order to control for this, we "trimmed" this figure by considering that a firm spends on R&D, when registering an expenditure of at least the cost of one researcher, for the case of small firms, one researcher and one technician, for medium firms, and two researchers and two technicians, for large firms, for a year. Costs are calculated using data from Chilean National Innovation Survey 2009, estimating the minimum number of R&D employees for a typical Chilean firm that spend on R&D, by firm size, and the typical wage, by employee type and relative to GDP per capita, and adjusted for the relative weight of wages in each country. This approach may under-report R&D expenditures by small firms—even some that are highly innovative—but such an adjustment must be made in order to systematically examine the data that follows.

The region also exhibits interesting patterns in R&D spending (Figure 2). Eight per cent of firms in LAC reported R&D expenditures. This figure is notably higher in the region's largest countries, twice the rates in small and Caribbean countries. However, the amount of R&D expenditure is low. On average, R&D expenditures are equivalent to less than one per cent (0.6 per cent) of annual sales. In large countries, R&D expenditures are valued at 1 per cent of annual sales, while this average is less than 0.4 per cent elsewhere. R&D investments in the region are also more skewed: a few very large investors generally represent a significant proportion of the

total national effort on R&D. Indeed, on average across the LAC countries, the firm that spends the most on R&D accounts for 30 per cent of total national manufacturing sector R&D spending. Among the 7 per cent of firms in LAC that reported spending on R&D, one in four firms spent more than US$135,000 in 2009.

Figure 2. Participation in Innovation Activity *(percentage of firms)*



Source: Authors' calculations using Enterprise Surveys 2010.

Almost 14 per cent of LAC firms filed for IPR between 2008 and 2010, with larger economies seeing higher rates of applications (Figure 2). This figure is significantly lower than the percentage of innovative firms (29 per cent). The low level of IPR use by manufacturing firms suggests a lack of novelty of innovations, and this is true even when we use a definition of innovation that is restricted to novel products or processes only. This means that even in the case of novel products or processes (in the firm's market or industry), much of the innovation in the region is based on the adoption and adaptation of technologies developed elsewhere, implying to some extent that they do not qualify for the international standards of novelty required for the granting of IPRs.

The rate of firms applying for IPRs, however, differs strongly across industries: in large economies for which we have data for several economic sectors, rates for patent applications mirror patterns in innovation. Almost thirty-six per cent of manufacturers of chemicals and plastics applied for a patent, while less than one in four textile and food manufacturers filed for IPR. The lowest share of IPR applicants, in large economies, occurred among fabricated metal and equipment manufacturers, at 13 per cent (Table 2).

Table 2. Share of Firms Applying for Intellectual Property Rights

Industry*	**Average****
Food/Beverages	21.2
Textiles & Garments	24.1
Chemicals & Rubber/Plastics	35.7
Fabricated metals & Machinery/Equip.	13.3

*Average among large countries with comparable data and survey designs (Argentina, Chile, Colombia, Mexico, and Peru).
**Chosen based on stratification designs in selected, large countries
Source: Own calculation using Enterprise Surveys 2010.

4. Who is Innovating?

Innovation behaviour differs across firms and countries. Not all firms rely on innovation as a means to increase economic performance, nor are all firms able to invest in innovation and transform internal knowledge into new competitive advantages. Several firm characteristics have recurrently been identified as factors that increase the likelihood of engagement in innovation, although patterns of firm innovation behaviour tend to differ between advanced and developing countries as well as within developing countries.

In general, firm size, firm productivity level (proximity to the technology frontier) and exporting orientation in developing country firms are often positively associated with firms' propensity to innovate and invest in innovation. In contrast, evidence regarding the role of age in explaining firm innovation is more mixed (Almeida and Fernandes, 2008; Crespi and Zuñiga, 2012).

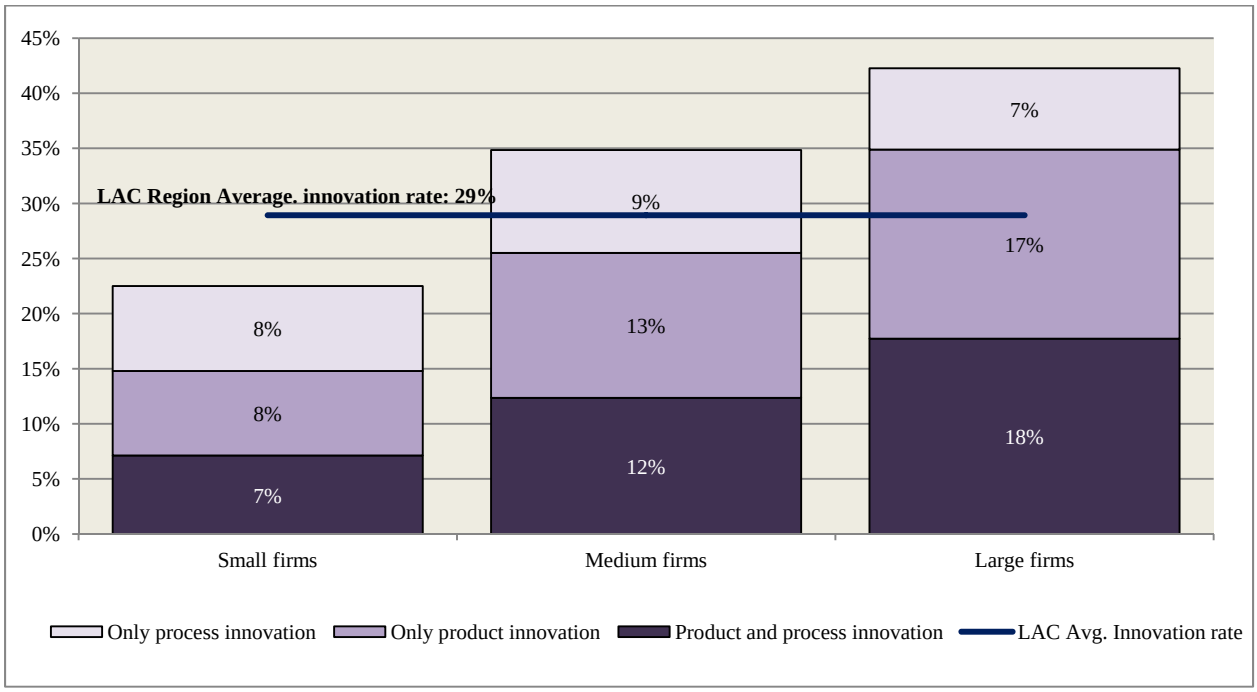
Large-size firms enjoy numerous advantages regarding innovation: a larger spread of R&D fixed costs over greater output (Cohen and Levinthal, 1989), economies of scope relating to R&D production and R&D diversification, easier access to finance, and better appropriation of external knowledge spillovers (Crespi and Zuñiga, 2012) enable larger firms to be better positioned to take advantage of innovation investments. It is also argued that small firms have more flexibility and adaptability (and less complex organizational structures), which favours innovation and the development of new projects (Acs and Audretsch, 1988).[7]

With respect to exporting, the rationale behind the association with innovation is related to the two types of effects that enhance firms' propensity to invest in innovation: the "competition" effect associated to international markets and the "learning" effects that derive from exporting. Experience in export markets leads firms to "learn" and acquire new skills in order to meet international product standards. Furthermore, firms must guarantee product quality and timely delivery of their orders to satisfy foreign customers. Several studies report evidence of the positive incidence of exporting on firms' R&D investment and innovation: Braga and Willmore (1991) for Brazilian firms and Alvarez (2001) for Chilean firms, among others.

The Enterprise Surveys found that large firms are more innovative than small- and medium-sized ones (Figure 3). More than four out of ten large manufacturing firms innovated, introducing either a new or significantly improved product or process.[8] Thirty-four per cent of medium firms and 23 per cent of small firms reported similar innovations. Moreover, 18 per cent of large firms in LAC report both a product *and* a process innovation compared to 12 per cent of medium firms and only 7 per cent of small ones. Exporting firms tend to innovate—either product or process—more than non-exporters (39 per cent of exporters versus 25 per cent of non-exporters)[9] (Figure 4). Similarly, firms operating in markets with almost no competitors report lower innovation rates than firms that compete with two or more firms in their main market. However, consistent with previous findings,[10] the relationship between innovation rates and competitive pressures appears to be hump-shaped. While 40 per cent of firms that face two to five competitors innovate, the proportion of firms that introduced product or process innovation decreases to 32 per cent for firms with five or more competitors (Figure 5).

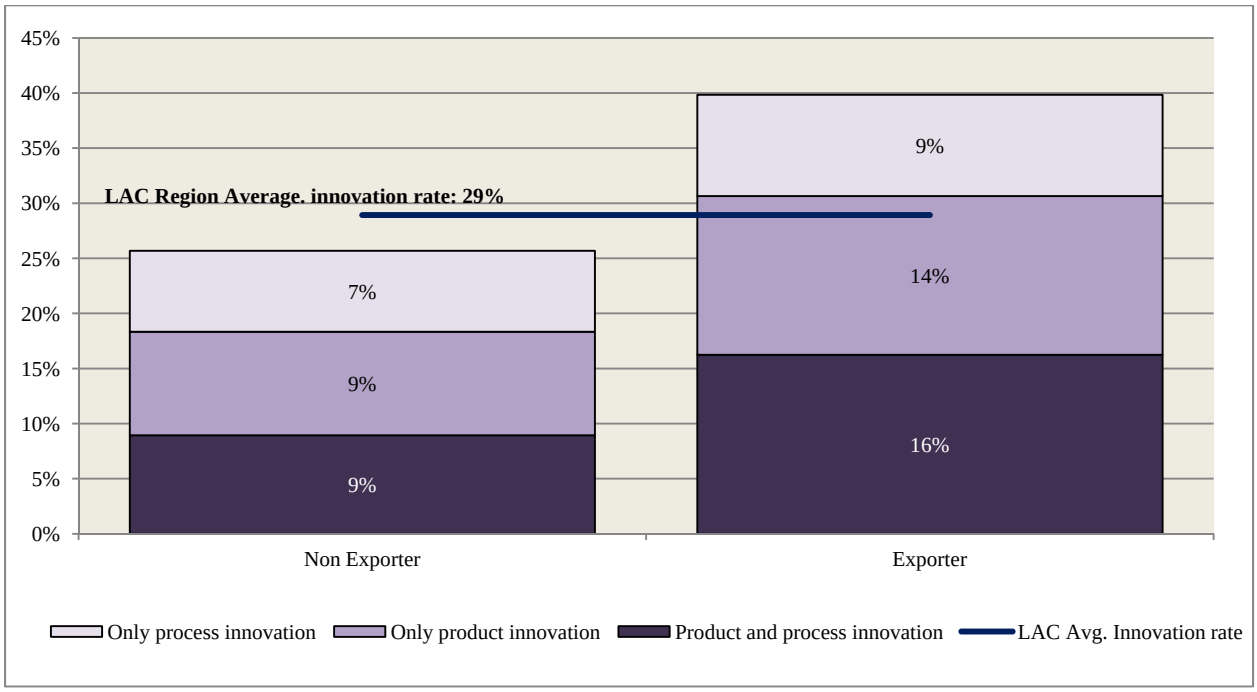
[7] In advanced countries, the role of small firms as agents of radical innovation has recurrently been stressed particularly in the case of emerging technologies (new technological paradigms).
[8] Cases with less than five firms per size category in a country are excluded from averages.
[9] Exporting firms are those that derive at least 10 per cent of sales from direct exports.
[10] See Arnold, Nicoletti, and Scarpetta (2008) for a detailed review of the literature.

Figure 3. Innovation Rates by Firm Size *(percentage of firms)*



Source: Authors' calculation using Enterprise Surveys 2010.

Figure 4. Innovation Rates by Export Profile (percentage of firms)

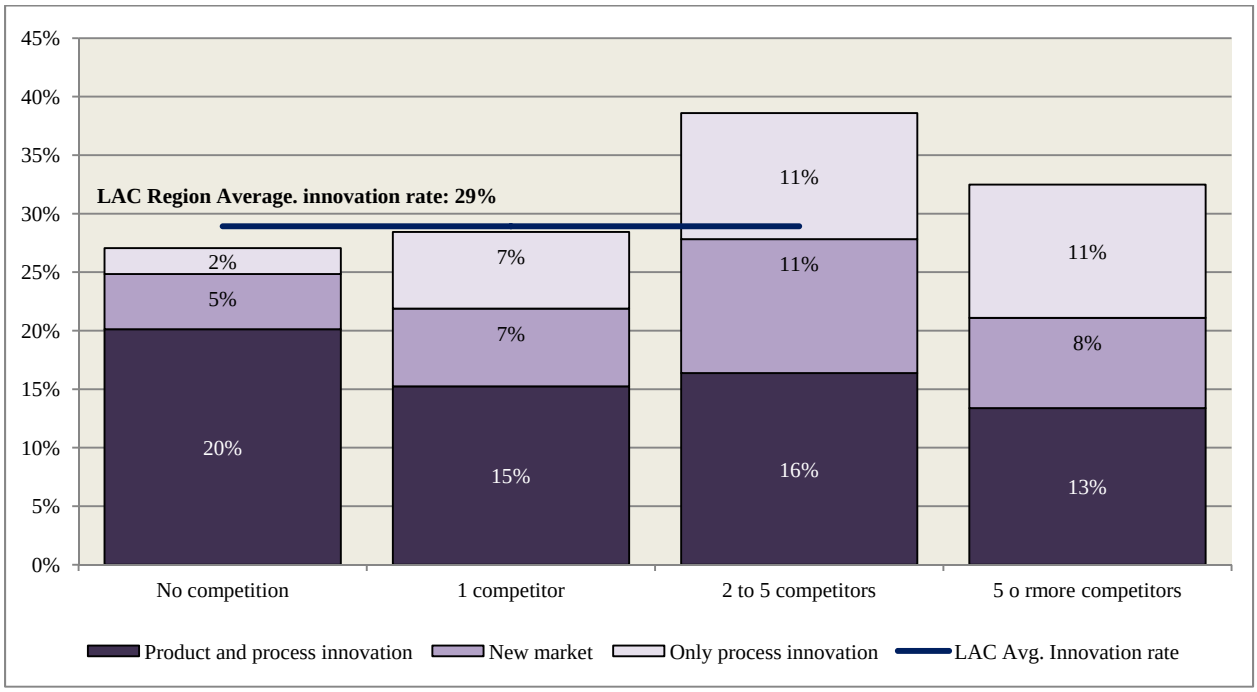


Source: Authors' calculation using Enterprise Surveys 2010.

We also explore the relationship between the size of the urban area where the firm is located and its propensity to innovate. A growing literature on the geography of innovation indicates that knowledge has important tacit components, so its transfer is sensitive to distance in the extent that it requires personal interaction (Asheim and Gertler, 2005). Despite this compelling rationale, an analysis of the average innovation rates by the size of the urban area where the firm is located did not reveal evidence of any significant correlation. This could be the result of measurement problems (as perhaps the size of the urban area is an indicator which is too general as to capture true economies of agglomeration) or it could indicate inherent weaknesses in the linkages within local innovation systems.

Finally, older firms (created more than 10 years ago) report innovations rates slightly higher than those of younger firms, although the difference is not statistically significant (30 versus 25 per cent, respectively). This result contrasts somewhat with findings from the literature, which suggest that young firms are more likely to innovate.

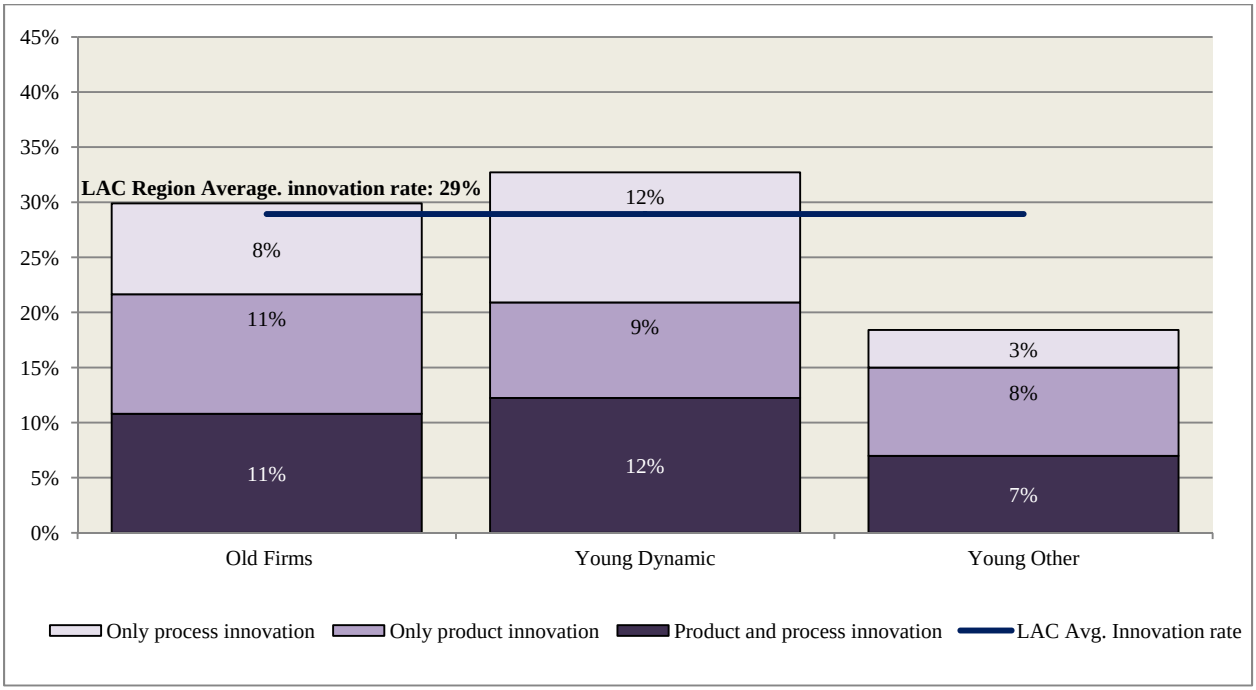
Figure 5. Innovation Rates by Number of Competitors *(percentage of firms)*



Note: Statistics relative to the number of competitors does not include the smallest Caribbean countries.
Source: Authors' calculation using Enterprise Surveys 2010.

The data from the Enterprise Surveys also reveal that young firms in LAC are heterogeneous, with a wider dispersion in the share of firms innovating. To understand this volatility, the innovation behaviour of young firms was analysed according to their dynamic profiles. Young firms are considered to be dynamic if they sell output in foreign markets, were founded based on new products, or created more employment since their founding than the median firm in their countries (Acs and Szerb, 2011). Dynamic young firms exhibit significantly higher innovation rates than other young firms. This result somewhat conciliates the results with the literature given that their innovation rates are higher compared to old firms (though not significantly) and higher (significantly) relative to young, non-dynamic firms (Figure 6).

Figure 6. Innovation Rates by Firm Age *(percentage of firms)*



Source: Authors' calculation using Enterprise Surveys 2010.

5. Who is Spending on Research and Development and Using IPRs?

An association between size and propensity to invest in R&D has been reported for firms in most countries in the Latin America and Caribbean region where systematic innovation surveys have been conducted (Benavente, 2006; Crespi and Peirano, 2007). Firm size plays a big role in R&D spending and in the likelihood that they will file IPR applications. Twice as many large firms have R&D expenditures than SMEs. Almost twenty-four per cent of large firms invested in R&D, nearly ten times the share of small firms that did so (Table 3). Nearly 30 per cent of large firms reported applying for an IPR, four times more frequently than small firms (7 per cent) and nearly two more frequently than medium-sized firms (17 per cent).

Exporting firms in LAC are three times more likely than non-exporting firms to perform R&D (17 per cent of exporters versus 5 per cent of non-exporters). Almost 30 per cent of exporters file for IPR, compared to 10 per cent of non-exporters. In the same vein as before, an inverted U relationship was also found between the found between the number of competitors and the share of firms applying for IPRs. Similar to the case with innovation outcomes, no large

differences were found between firms located in large versus small cities when evaluating their propensity to invest in R&D or their filing for IPRs.

Older firms are more likely to spend on R&D and to file for IPRs than young ones—though dynamic young firms engage in R&D nearly as much as older firms and file for IPR at higher rates. Thus, young, dynamic firms appear to be highly innovative, invest in R&D, and introduce innovation in their processes and products at high rates.

Table 3. Share of Firms Spending on R&D

Firms Size	**Average***
Small Firms	**3.0**
Medium Firms	**9.9**
Large Firms	**23.9**
Export Profile**	
Non Exporter Firms	**5.1**
Exporter Firms	**17.3**
Age and Dynamism***	
Young Non Dynamics Firms	**3.9**
Young Dynamics Firms	**7.0**
Old Firms	**9.1**

*Estimated using national averages by firms characteristic.
** Exporting firms are those who derive at least 10 per cent of sales from direct exports.
*** Young firms are dynamic if they sell output in foreign markets, were founded based on new products, or created more employment since being founded than the median firm in their countries.
Source: Authors' calculation using Enterprise Surveys 2010.

Additionally, there are notable differences in the share of firms spending on R&D across industries. In large economies, a larger share of firms in the chemicals and plastics sector spend on R&D (35.7 per cent) than in other manufacturing sectors. Roughly one out of every five manufacturers in food manufacturing as well as textile manufacturers spend on R&D; only 13.3 per cent of firms in the industry of fabricated metals and equipment spend on R&D (Table 4).

The use of public instruments for innovation is low across the region. The average share of LAC firms that used public support for innovation was 6.2 per cent. The high rate of innovation is likely due to technology adoption and adaptation. Few firms have followed innovation strategies based on R&D and aimed at producing innovations that need to be protected by some form of IPR. Large and export firms produce more innovations based on R&D; thus, they are more intensive users of public instruments. These figures are low when compared with the standard in developed countries. Indeed, the proportion of firms using public support for innovation in LAC (7 per cent) is two times less than the OECD average (18 per cent).[11]

Table 4. Share of Firms Spending on R&D

Industry*	**Average****
Food/Beverages	**21.2**
Textiles & Garments	**24.1**
Chemicals & Rubber/Plastics	**35.7**
Fabricated metals & Machinery/Equip.	**13.3**

*Average among large countries with comparable data and survey designs (Argentina, Chile, Colombia, Mexico, and Peru)
**Chosen based on stratification designs in selected, large countries
Source: Authors' calculation using Enterprise Surveys 2010.

In addition to analysing the share of firms that invest in R&D in LAC, we explore their level of spending compared with the level of R&D spending of firms considered the "top 20 global R&D champions." In levels, LAC performance is relatively modest: among all the LAC firms that invested in R&D, 82 per cent spent less than US$100,000 (PPP) in 2010. Considering all spending in R&D in LAC as coming from one company, this company would rank 13th on the ranking cited. In relative terms, this means that the top 20 best R&D firms in the world (Tables 5 and 6) invest 22 times more than the aggregate of all LAC companies. Adding Brazil (using the 2008 Survey of Technological Innovation (PINTEC)) to these numbers, R&D investment in the continent almost doubles, reducing the difference with the amount spent for the top 20 companies, to 12 times. It is important to note that even if Brazil's GDP represents 30 per cent of

[11] Unfortunately, we do not have comparable figures for other developing countries.

the GDP of the region, Brazilian firms' spending in R&D accounts for 50 per cent of R&D spending, revealing the strong concentration of effort in one country.

Table 5. R&D Spending by Top 20 Firms and LAC

Description	R&D 2010 (US$ millions)	R&D as a % of sales	Total sales
Top 20 firms	141,781	8.6%	1,656,970
Latin America and the Caribbean*	6,290	0.3%	1,910,000
Latin America and the Caribbean**	12,087	0.4%	2,815,949
Ratio (Top 20/LAC*)	22.5	26.0	0.9
Ratio (Top 20/LAC**)	11.7	19.9	0.6

* Countries in Enterprise Survey.
** Adding Brazil data.
Source: Enterprise Surveys and Bloomberg data, Key Booz & Company The Global Innovation 1000, "Why Culture is Key"

Table 6. Top 20 R&D Spending Firms

Rank 2010	Rank 2009	Company	2010, US$ millions	Change from 2009	As a % of sales	Sales	HQ location	Industry
1	1	Roche holding	9646	1.5	21.1	45,716	Europe	Healthcare
2	5	Pfizer	9413	20	13.9	67,719	North America	Healthcare
3	6	Novartis	9070	21.4	17.9	50,670	Europe	Healthcare
4	2	Microsoft	8714	-3.3	14	62,243	North America	Software and Internet
5	14	Merck	8591	53	18.7	45,941	North America	Healthcare
6	4	Toyota	8546	0.7	3.9	219,128	Asia	Auto
7	10	Samsung	7873	23.2	5.9	133,441	Asia	Computing and Electronics
8	3	Nokia	7778	-0.8	13.8	56,362	Europe	Computing and Electronics
9	11	General Motors	6962	16	5.1	136,510	North America	Auto
10	7	Johnson & Johnson	6844	-2	11.1	61,658	North America	Healthcare
11	13	Intel	6576	16.3	15.1	43,550	North America	Computing and Electronics
12	18	Panasonic	6176	11	6.1	101,246	Asia	Computing and Electronics
13	9	GlaxoSmithKline	6127	0.3	14	43,764	Europe	Healthcare
14	15	Volkswagen	6089	19.4	3.6	169,139	Europe	Auto
15	12	IBM	6026	3.5	6	100,433	North America	Computing and Electronics
16	8	Sanofi-Aventis	5838	-4	14.5	40,262	Europe	Healthcare
17	19	Honda	5704	5.2	5.5	103,709	Asia	Auto
18	22	AstraZeneca	5318	20.6	16	33,238	Europe	Healthcare
19	17	Cisco Systems	5273	1.3	13.2	39,947	North America	Computing and Electronics
20	16	Siemens	5217	-1.4	5.1	102,294	Europe	Industrials

Source: Bloomberg data, Booz & Company The Global Innovation 1000, "Why Culture is Key"

If we look at the top performers in the region, only 4 per cent of companies in LAC spend a large amount of resources in R&D activities at least for the regional standard (more than US$500,000 [PPP]). What are the main features of these top-performing firms in R&D in Latin America? Do they have significant differences with firms that don't invest? We explore what makes some companies invest in R&D compared to the vast majority of firms in the region and in particular, the characteristics of "top performers" in R&D in LAC using a probit model (Table 7).

First of all, the findings reveal that the factors that influence significantly the probability of spending in R&D and being a regional top performer are similar. The only exception observed is for ownership: foreign companies have a positive and significant probability of being a top performer but this is not a strong predictor for engaging in R&D activities. This result suggests that Multinational Enterprises (MNEs) are not more likely to invest in R&D compared to other firms in LAC but when they do invest their level of the investment is significantly higher.

Exporting and high-productivity firms are more likely to spend more than US$500,000 (PPP) in R&D per year. However, the level of productivity of the firm is more important than exporting in determining R&D spending. These roles remain identical when the discriminating variable is the level of investment involved. Thus, there are more high-productivity firms investing, and in addition, they tend to invest larger amounts.

Finally, we observe that size is the most important factor influencing the probability of spending in R&D, but also being a top performer. Controlling by sub-region and economic sector (ISIC 3.1. at the two-digit level), medium and large companies are more likely to be “top performers” than small firms, increasing this probability by 4.6 per cent and 10.9 per cent, respectively. These marginal effects are even stronger when we consider the probability of spending in R&D: large firms in LAC have almost 20 per cent higher chances of engaging in R&D activities than small firms, showing that the availability of resources is a crucial aspect for R&D.

Table 7. Marginal Effects of the Probability of Spending in R&D and being a Top Performer on R&D[12]

	Model 1 Spending R&D		Model 2 R&D Top Performer	
	Coefficient	SE	Coefficient	SE
Young	-0.0102	0.013	-0.0037	0.007
Foreign Ownership	-0.0142	0.014	0.0108**	0.005
Export	0.0687***	0.010	0.0131***	0.005
High Productivity	0.0787***	0.011	0.0255***	0.005
Medium	0.0961***	0.012	0.0465***	0.015
Large	0.1826***	0.013	0.1093***	0.015
Sector Fixed effects	Yes		Yes	
Country Fixed effects	Yes		Yes	
Pseudo R-squared	0.1799		0.3287	
N	6051		5917	

Estimation is significant at 10% level (*), 5% level (**) or 1% level (***)
Source: Authors' calculation using Enterprise Surveys 2010.

[12] Estimation performed using a Probit model controlling by country and economic sector (ISIC 3.1. at the two-digit level) and clustering by country and sector groups. A firm is foreign owned if 50 per cent or more of the shares are owned by non-domestic capital.

6. Conclusion

Innovation is a relatively new concept for Latin American and Caribbean firms. Although indicators reflect high propensities to innovate, even larger than the average observed in developed economies, this statistical dissonance suggests that the way innovation is understood in the region differs widely from that of firms in more developed nations. Statistical evidence on the use of IPRs (based on an objective measure of performance) and the ratio of patenting firms relative to innovating firms present quite a different picture in which the figures observed for LAC firms are substantially smaller than the average of their OECD counterparts. In general, firms in LAC hardly invest in disembodied technology; therefore, such high innovation rates may likely reflect incremental and adaptive innovation (necessary for the use of foreign technology).

Nevertheless, in spite of such embryonic technological capacity, the available evidence enables corroboration of the importance of innovation in building sustainable economic advantages, providing a rationale for public support. Firms that invest in R&D or innovate are more likely to patent and have a stronger presence in international markets. These effects are stronger for product than process innovation. Furthermore, innovation activities are found to be strongly associated with firm size; small- and medium-sized firms are more handicapped to participate in the innovation race which limits, in turn, their potential to grow and become more competitive in international markets. Lastly, age by itself is not a preponderant factor if we do not consider innovation activity by firms. Those young firms that are highly innovative behave differently in terms of technological activity, and as such, can behave as change agents ("to climb the ladder").

From a policy standpoint, there is a great challenge for public policies to effectively increase firms' technology assets, facilitate access to finance for innovation and support more effective and articulated innovation systems. Given that bigger firms are more likely to innovate and access to (the limited) public policy instruments, it is important to pay special attention to SMEs. Creative and effective policy mechanisms are needed to target this group and alleviate innovation constraints that handicap perspectives of growth for these firms. Lastly, the findings also show that there is a special group of world-class MNEs that invest in R&D. They are an important share of the main performers of R&D in the region. Therefore, attracting this type of

companies should be emphasized in public policies regarding foreign direct investment. Similarly (although it is beyond the scope of this paper), the service sector needs to be better addressed by public policy, since it is the sector responsible for the overall low level of productivity observed in the region.

References

Acs, Z. and D. Audretsch. 1988. “Innovation in Large and Small Firms: An Empirical Analysis.” *American Economic Review* 78: 678-90.

Acs Z. and L. Szerb. 2011. *Global Entrepreneurship and Development Index.* Cheltenham, United Kingdom: Edward Elgar.

Almeida, R. and A. Fernandes. 2008. “Openness and Technological Innovations in Developing Countries: Evidence from Firm-Level Surveys.” *The Journal of Development Studies* 44(5): 701-27.

Alvarez, R. 2001. “External Sources of Technological Innovation in Chilean Manufacturing Industry.” University of Chile, Department of Economics. *Estudios de Economía* 28 (June): 53-68.

Anlló, G. and D. Suarez. 2009. "Innovación: Algo más que I+D. Evidencias Iberoamericanas a partir de las encuestas de innovación: Construyendo las estrategias empresariales competitivas." Buenos Aires, Argentina: CEPALREDES. Unpublished.

Arnold, J., G. Nicoletti and S. Scarpetta, 2008. "Regulation, Allocative Efficiency and Productivity in OECD Countries: Industry and Firm-Level Evidence." *OECD Economics Department Working Papers 616.*

Asheim, B.T. and M.S. Gertler, 2005. *The geography of innovation: regional innovation systems*. In: Fagerberg, J., Mowery, D., Nelson, R. (Eds.), The Oxford Handbook of Innovation. Oxford, University Press, Oxford, pp. 291–317.

Benavente, J. M. and R. Lauterbach, 2008. "Technological Innovation and Employment: Complements or Substitutes?" *European Journal of Development Research* 20(2): 318-29.

Braga, H. and L. Willmore. 1991. "Technological Imports and Technological Effort." *Journal of Industrial Economics* 39(4): 421–32.

Cohen, W. and D. Levinthal. 1989. "Innovation and Learning: The Two Faces of R&D." *Economic Journal* 99(397): 569–56.

Crespi, G. 2012. “Incentivos fiscales para la innovación empresarial.” in *Las Instituciones Fiscales de Mañana*. Washington, DC, United States: Inter-American Development Bank.

Crespi G. and R. Alvarez, 2011. "Financing Gaps and Innovation Gaps. New Evidence from Chile." Working Paper. Washington, DC United States: Inter-American Development Bank. Forthcoming.

Crespi, G. and F. Peirano. 2007. “Measuring Innovation in Latin America: What We Did, Where We Are and What We Want to Do.” Paper prepared for the United Nations University and Maastricht Social and Economic Research and Training Institute on Innovation and Technology (UNU-MERIT) Conference on Micro Evidence on Innovation in Developing Countries, 31 May - 1 June, Maastricht**.**

Crespi, G. and P. Zuniga. 2012. “Innovation and Productivity: Evidence from Six Latin American Countries.” *World Development* 4(2): 273-90.

Ginarte, J. and W. Park. 1997. “Determinants of Patent Rights: A Cross-national Study.” *Research Policy* 26 (3): 283-301.

Griffith, R., S. Redding, and J. Van Reenen. 2004. “Mapping the Two Faces of R&D: Productivity Growth in a Panel of OECD Industries.” *The Review of Economics and Statistics* 86(4): 883-95.

Griffith, R., E. Huergo, J. Mairesse, and B. Peters. 2006. “Innovation and Productivity across Four European Countries.” *Oxford Review of Economic Policy* 22(4): 483-98.

Griliches, Z. 1990. “Patent Statistics as Economic Indicators: A Survey.” *Journal of Economic Literature, American Economic Association* 28(4), 1661-1707.

Hall, R. and C. Jones. 1999. “Why Do Some Countries Produce So Much More Output per Worker than Others?” *Quarterly Journal of Economics* 114(1): 83-116.

Harhoff, D. and T. Korting. 1998. “Lending Relationships in Germany - Empirical Evidence from Survey Data.” *Journal of Banking & Finance*. Elsevier 22(10-11): 1317-53.

Kim, J-Y., T-Y. Park and K. Lee. 2013. “Catch-up by indigenous firms in the Software Industry and the Role of the Government in China: A Sectoral System of Innovation Perspective.”, forthcoming in *Eurasian Business Review*, 3(1), 2013.

Mairesse, J. and P. Mohnen. 2010. “Using Innovations Surveys for Econometric Analysis.” *NBER Working Papers* 15857. Cambridge, United States: National Bureau of Economic Research.

Mohnen, P. and B. Hall. (2013). “Innovation and Productivity: An Update”, forthcoming in *Eurasian Business Review*, 3(1).

Navarro, J. C., J. J. Llisterri and P. Zuñiga. 2010. “The Importance of Ideas: Innovation and Productivity in Latin America.” in Pagés, C. (ed.) *The Age of Productivity: Transforming Economies From the Bottom Up. Development in the Americas*. Washington, DC, United States: Inter-American Development Bank/Palgrave-McMillan.

Organisation for Economic Co-operation and Development (OECD). 2009a. *Innovation in Firms: A Microeconomic Perspective*. Paris, France: OECD.

---. 2009b. *Patent Statistics Manual.* Paris, France: OECD.

---. 1994. *The Measurement of Scientific and Technological Activities using Patent Data as Science and Technology Indicators*. Paris, France: OECD.

Rouvinen, P. 2002. “Characteristics of Product and Process Innovators: Some Evidence from the Finnish Innovation Survey.” *Applied Economics Letters* 9(9): 575-80.

Vivarelli, M. 2013. “Technology, Employment and Skills, an Interpretative Framework.”, forthcoming in *Eurasian Business Review*, 3(1)

Technical Appendix – The Enterprise Survey

An Enterprise Survey is a firm-level survey of a representative sample of an economy's private sector. The World Bank's Enterprise Surveys (ES) has been conducting these surveys since 2000 for key manufacturing and service sectors in every region of the world. The ES cover a broad range of business environment topics including access to finance, corruption, infrastructure, crime, competition, and performance measures.

Enterprise Surveys in Latin America are jointly funded with the Inter-American Development Bank (IDB), and surveys in the Caribbean are jointly funded with IDB and COMPETE Caribbean. It includes the list of following countries: Antigua, Argentina, Bahamas, Barbados, Belize, Bolivia, Brazil, Chile, Colombia, Costa Rica, Dominica, Dominican Republic, Ecuador, El Salvador, Grenada, Guatemala, Guyana, Honduras, Jamaica, Mexico, Nicaragua, Panama, Paraguay, Peru, C, Saint Lucia, Saint Vincent and the Grenadines, Suriname Trinidad and Tobago, Uruguay and Venezuela.

Size, scope and sampling methodology:

- The Enterprise Survey is answered by business owners and top managers.
- In each country, businesses in the cities/regions of major economic activity are interviewed.
- Typically 1200-1800 interviews are conducted in larger economies, 360 interviews are conducted in medium-sized economies and for smaller economies, 150 interviews are conducted.
- The manufacturing and services sectors are the primary business sectors of interest. This corresponds to firms classified with ISIC codes 15-37, 45, 50-52, 55, 60-64, and 72 (ISIC Rev.3.1). Services firms include construction, retail, wholesale, hotels, restaurants, transport, storage, communications, and IT.
- Aimed at formal (registered) companies with 5 or more employees are targeted for interview.
- Firms with 100 per cent government/state ownership are not eligible to participate in an Enterprise Survey.

Structure and content of the surveys:

- The Enterprise Surveys Unit uses two instruments: the Manufacturing Questionnaire and the Services Questionnaire.
- The standard Enterprise Survey topics include firm characteristics, gender participation, access to finance, annual sales, costs of inputs/labour, workforce composition, bribery, licensing, infrastructure, trade, crime, competition, capacity utilization, land and permits, taxation, informality, business-government relations, innovation and technology, and performance measures.

Sampling and weights:

The sampling methodology for Enterprise Surveys is stratified random sampling. The strata for Enterprise Surveys are firm size, business sector, and geographic region within a country:

- Firm size levels are 5-19 (small), 20-99 (medium), and 100+ employees (large-sized firms). Enterprise Surveys oversample large firms.
- Sector breakdown is usually manufacturing, retail, and other services. For larger economies, specific manufacturing sub-sectors are selected as additional strata on the basis of employment, value-added, and total number of establishments.
- Geographic regions within a country are selected based on which cities/regions collectively contain the majority of economic activity.

For further information, please visit the official Enterprise Survey web page: http://www.enterprisesurveys.org.

The UNU-MERIT WORKING Paper Series

2013-01 *Effects of innovation on employment in Latin America* by Gustavo Crespi and Ezequiel Tacsir

2013-02 *Revisiting the porter hypothesis: An empirical analysis of green innovation for the Netherlands* George van Leeuwen and Pierre Mohnen

2013-03 *Impact of external knowledge acquisition strategies on innovation - A comparative study based on Dutch and Swiss panel data* by Spyros Arvanitis, Boris Lokshin, Pierre Mohnen and Martin Wörter

2013-04 *Interactive knowledge exchanges under complex social relations: A simulation modelRobin* by Cowan and Anant Kamath

2013-05 *Innovation systems framework: still useful in the new global context?* by Michiko Iizuka

2013-06 *The importance of intrinsic and extrinsic motivation for measuring IQ* by Lex Borghans, Huub Meijers and Bas ter Weel

2013-07 *Firms' innovation capability-building paths and the nature of changes in learning mechanisms: Multiple case-study evidence from an emerging economy* by Paulo N. Figueiredo , Marcela Cohen and Saulo Gomes

2013-08 *A set of time series data labour market stocks and flows for the Netherlands 1980 to 2010* by Manuel Müllers, Joan Muysken and Erik de Regt

2013-09 *Designing an optimal 'tech fix' path to global climate stability: R&D in a multi-phase climate policy framework* by Adriaan van Zon and Paul A. David

2013-10 *Complementarity between internal knowledge creation and external knowledge sourcing in developing countries* by Jun Hou and Pierre Mohnen

2013-11 *Summarizing large spatial datasets: Spatial principal components and spatial canonical correlation* by Samyukta Bhupathiraju, Bart Verspagen and Thomas Ziesemer

2013-12 *Regional systems of innovation in the Arab region* by Samia Satti Osman Mohamed Nour

2013-13 *Development and social justice: Education, training and health in Sudan* by Samia Satti Osman Mohamed Nour

2013-14 *The economic importance and impacts of intellectual property rights (IPRs) in Sudan* by Samia Satti Osman Mohamed Nour

2013-15 *Overview of knowledge economy in the Arab region* by Samia Satti Osman Mohamed Nour

2013-16 *The importance (impacts) of knowledge at the macro-micro levels in the Arab Gulf countries* by Samia Satti Osman Mohamed Nour

2013-17 *Political determinants and impact analysis of using a cable system as a complement to an urban transport system* by Diego Escobar-García, Francisco García-Orozco and Carlos Cadena-Gaitán

2013-18 *Women entrepreneurs in the informal economy: Is formalization the only solution for business sustainability?* By Shyama V. Ramani, Ajay Thutupalli, Tamas Medovarszki, Sutapa Chattopadhyay, Veena Ravichandran

2013-19 *Heterogeneity in innovation strategies, evolving consumer preferences and market structure: An evolutionary multi-agent based modelling approach* by Salih Çevikarslan

2013-20 *Optimal patent length and patent breadth in an R&D driven market with evolving consumer preferences: An evolutionary multi-agent based modelling approach* by Salih Çevikarslan

2013-21 *Innovation and productivity: An update* by Pierre Mohnen and Bronwyn H. Hall

2013-22 *Fathers' use of parental leave. What do we know?* by Nevena Zhelyazkova

2013-23 *Eliciting Illegal migration rates through list randomization* by David McKenzie and Melissa Siegel

2013-24 *How do ICT firms in Turkey manage innovation? Diversity in expertise versus diversity in markets* by Semih Akçomak, Erdal Akdeve and Derya Fındık

2013-25 *Dynamic models of R&D, innovation and productivity: Panel data evidence for Dutch and French manufacturing* by Wladimir Raymond, Jacques Mairesse, Pierre Mohnen and Franz Palm

2013-26 *Centre-based versus home-based childcare* by Robert Bauchmüller

2013-27 *Microeconometric evidence of financing frictions and innovative activity* by Amaresh K Tiwari, Pierre Mohnen, Franz C Palm and Sybrand Schim van der Loeff

2013-28 *Innovation for economic performance: The case of Latin American firms* by Elena Arias Ortiz, Gustavo Crespi, Ezequiel Tacsir, Fernando Vargas and Pluvia Zuñiga